BIOLOGICAL EVALUATION OF GYPSY MOTH

AT

CHESAPEAKE MARSHLANDS NATIONAL WILDLIFE REFUGE COMPLEX

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ABSTRACT

In the Fall of 2001, USDI Fish and Wildlife Service personnel and USDA Forest Service personnel conducted a gypsy moth egg mass survey at Chesapeake Marshlands National Wildlife Refuge Complex (CMNWRC) to evaluate the efficacy of the 2001 treatment areas and to assess the potential for defoliation and the need for treatment in 2002. Current populations are sufficient to cause noticeable defoliation on 643 acres. In order to protect Delmarva fox squirrel habitat, treatment is recommended in these areas in 2002.

METHODS

The survey area consisted of all areas that were treated in 2001 and in stands that were previously identified as being fair or good fox squirrel habitat with a high potential for gypsy moth defoliation (Whiteman and Onken, 1994). The survey was also conducted in stands acquired in stands after 1994 that have a significant oak component. These new stands would have a high potential for gypsy moth defoliation and also good fox squirrel habitat. The 46 stands that were surveyed are presented in Figure 1.

Within each stand, gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a $1/40^{th}$ acre fixed radius plot was established. The plots consisted of a tally of all the new (2001) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The location of the survey plots are shown in Figures 2a-2d and the survey results are summarized in Tables 1. Overall egg mass densities ranged from 0-48,480 and averaged 992 egg masses per acre. Egg mass densities are high in Stands 6, 9, 32, 67, 75 and the southern portion of 62. Egg mass densities in Stands 1, 3, 4, 5, 7, 10, 11, 12, 13, 21, 23, 27, 29, 33, 34, 35, 37, 39, 40, 41, 44, 51, 56, 57, 58, 60, 61, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 76 and the rest of 62 are not expected to cause noticeable defoliation . Egg mass lengths at CMNWRC average 29 mm, but varied greatly in the 46 surveyed stands ranging from 19-58 mm.

Egg mass survey results for the 21 stands (1,709 acres) treated in 2001 are summarized in Table 2. Overall, the average egg mass density was reduced 99 percent from the pre-treatment level of 2,676 to the current level (post-treatment) of 29 egg masses per acre. Egg mass densities were reduced by at least 93 percent in nineteen stands. Although 19 acres of defoliation were detected at CMNWRC and 1,287 acres were detected in the vicinity in 2001, no defoliation was detected in the treatment areas (Figure 3).

Figure 1. -- Stands surveyed for gypsy moth egg masses at Chesapeake Marshlands NWR Complex, Fall 2001.

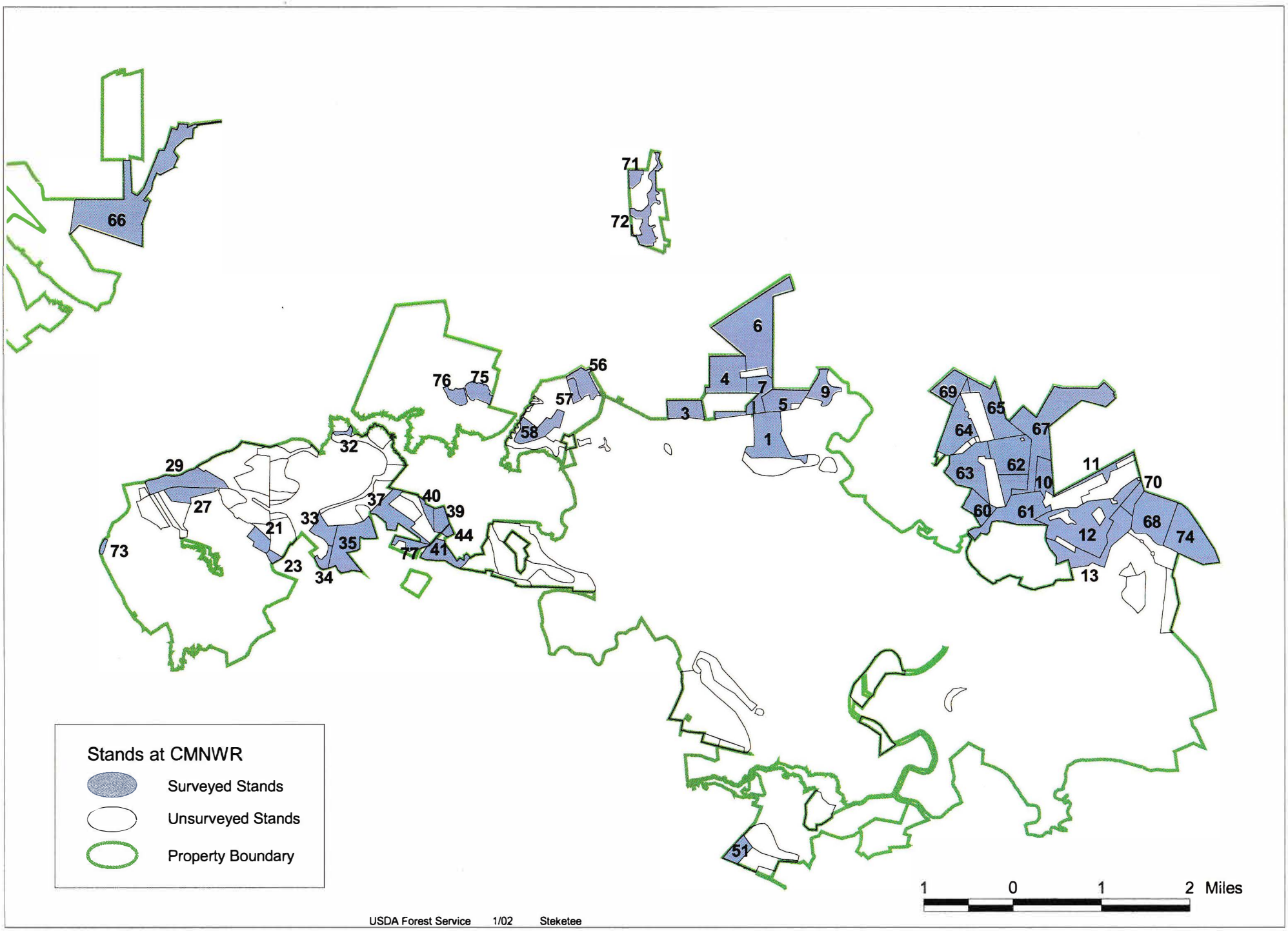


Figure 2a. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, Fall, 2001 (North Side and Southern Stand).

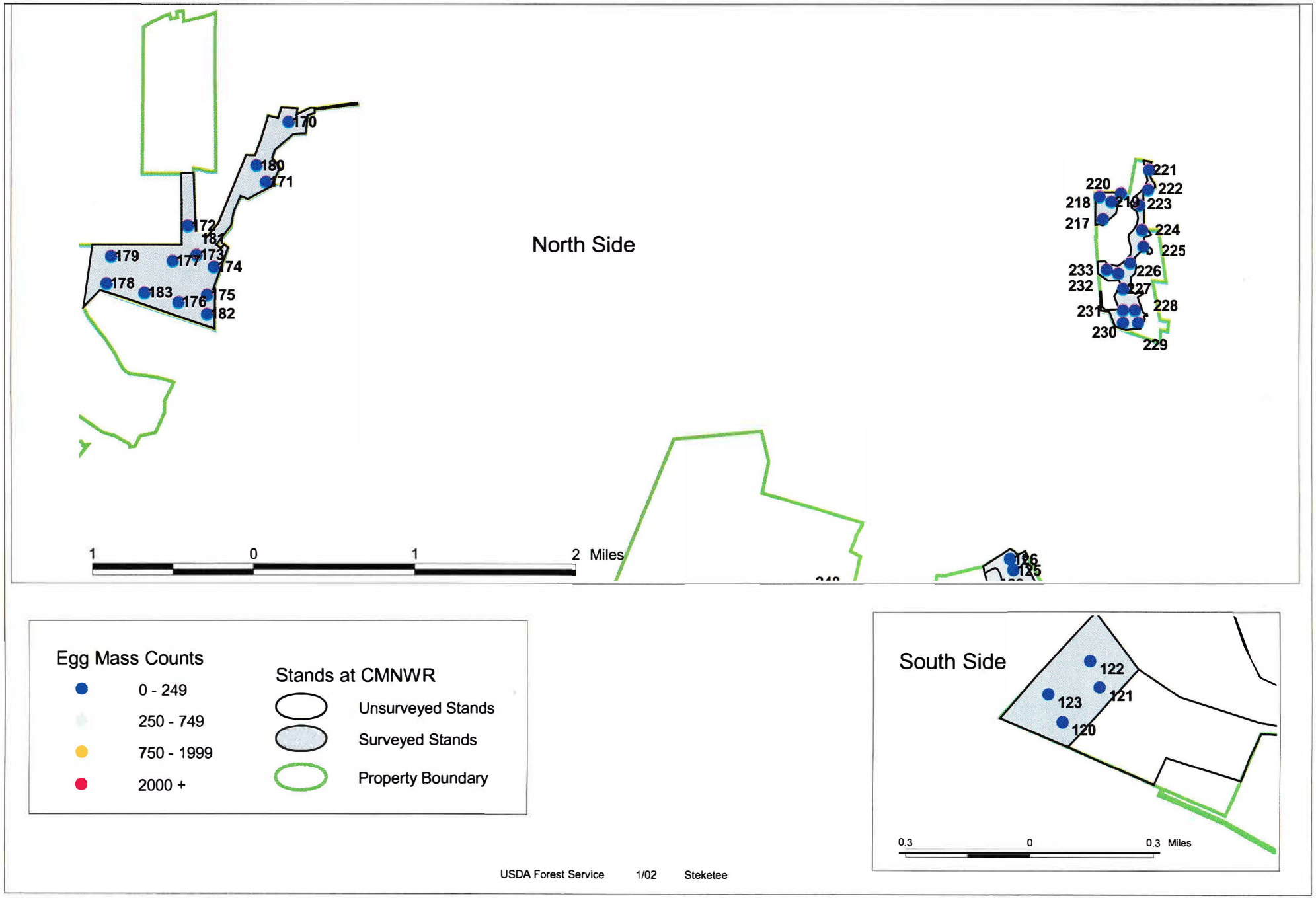


Figure 2b. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, Fall, 2001 (West Side).

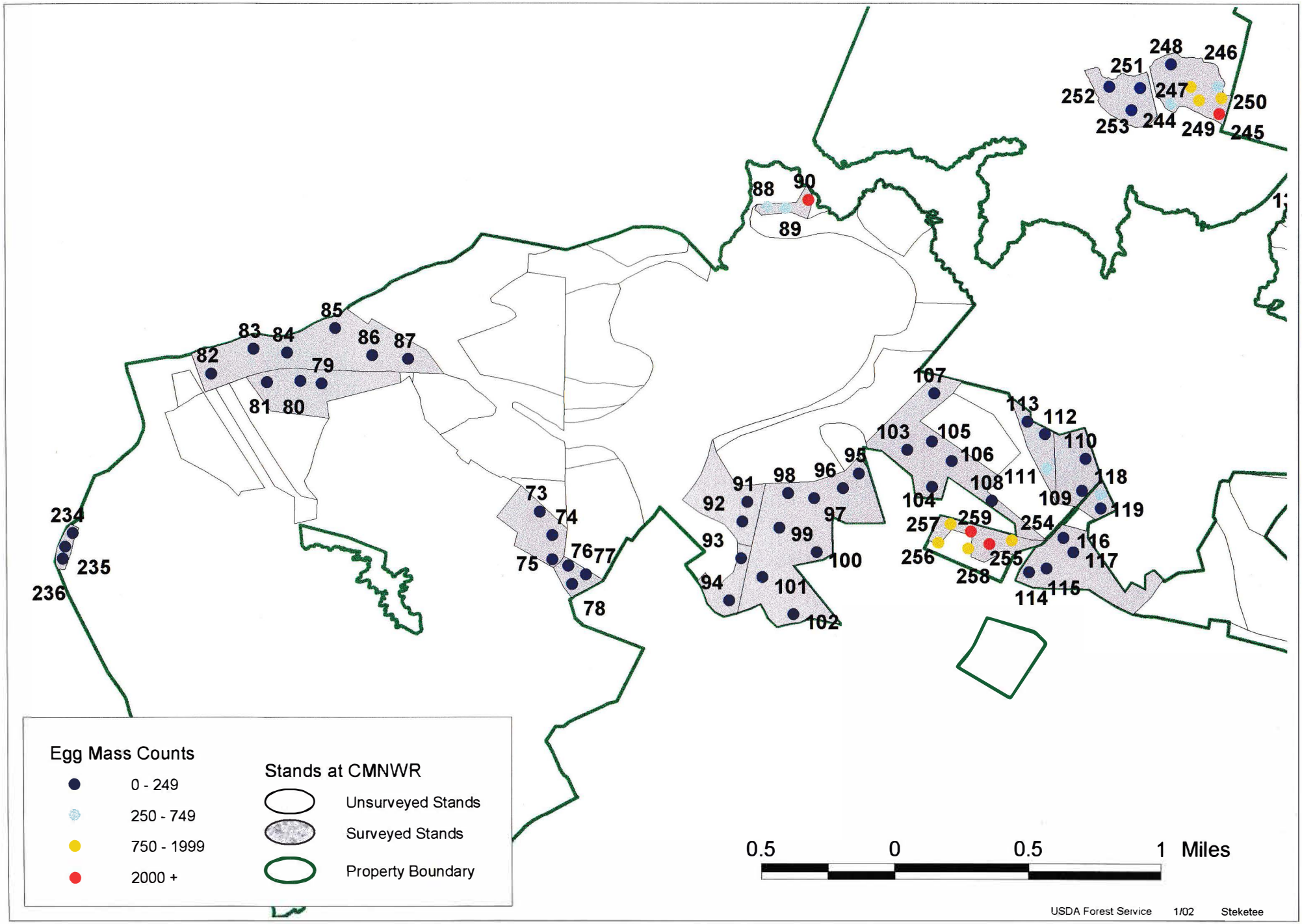


Figure 2c. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, Fall, 2001 (Center).

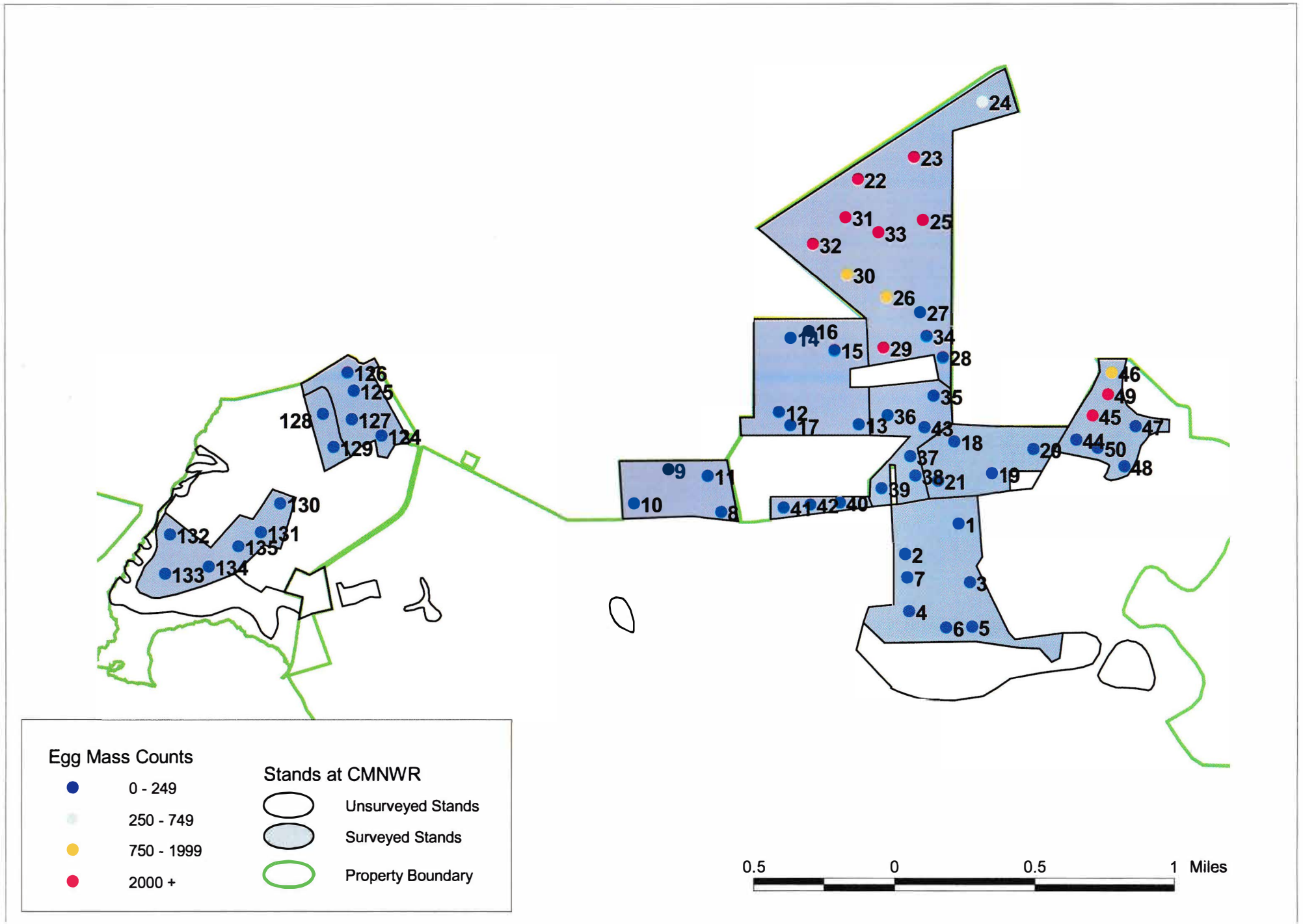


Figure 2d. -- Gypsy moth egg mass survey plot locations at Chesapeake Marshlands NWR Complex, Fall, 2001 (East Side).

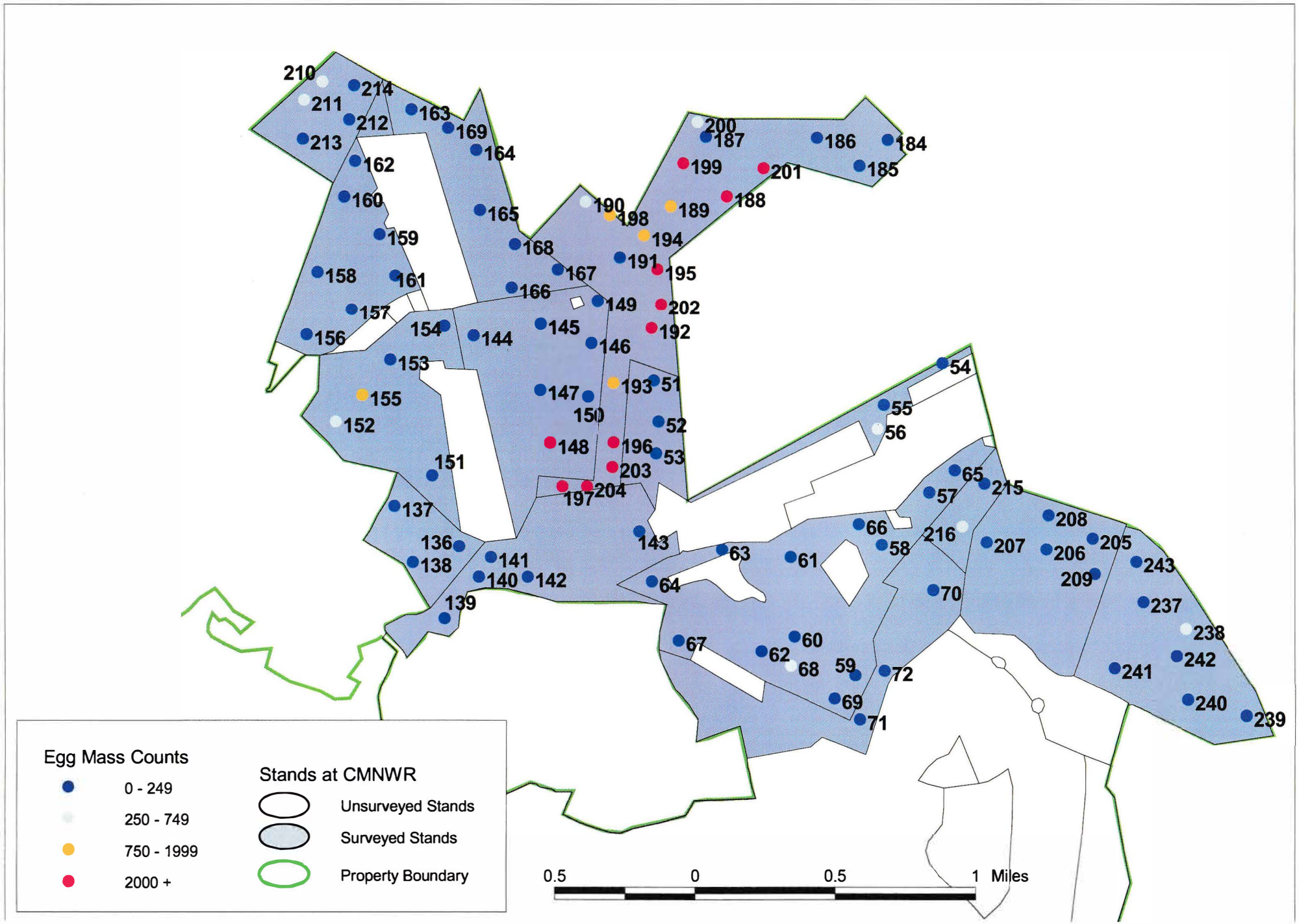
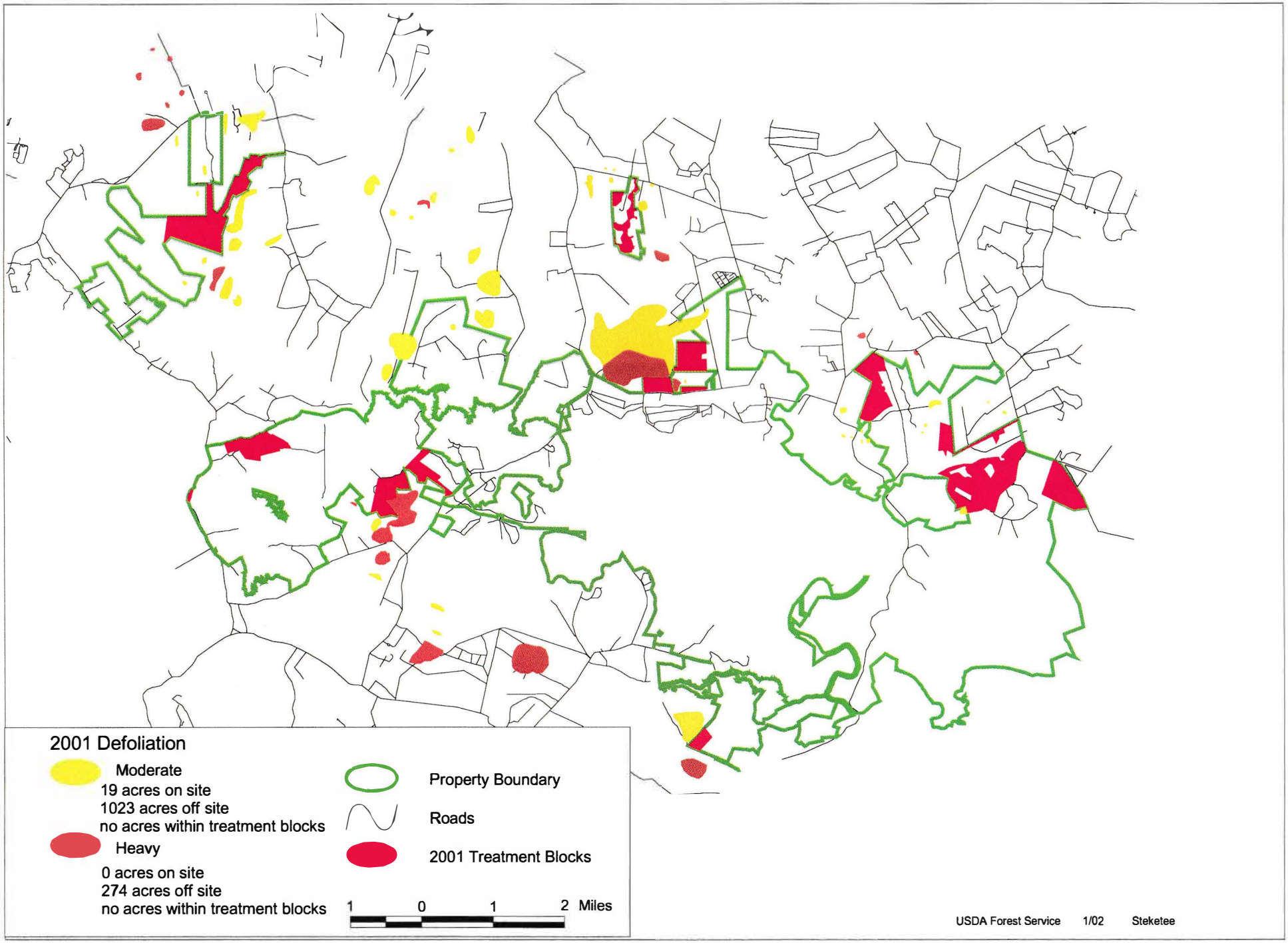


Figure 3. -- Results of the gypsy moth defoliation survey at the Chesapeake Marshlands NWR Complex on June 19, 2001, along with the 2001 gypsy moth treatment blocks.



DISCUSSION

All the surveyed stands are valued habitat for the Delmarva fox squirrel. Gypsy moth defoliation would have a negative impact on the value of these stands for this squirrel.

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

The survey results indicate that heavy defoliation is likely to occur on approximately 57 acres and moderate defoliation on 586 acres at CMNWRC in 2002.

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 illustrates how this information can be used to correlate the predicted defoliation of Stand 6.

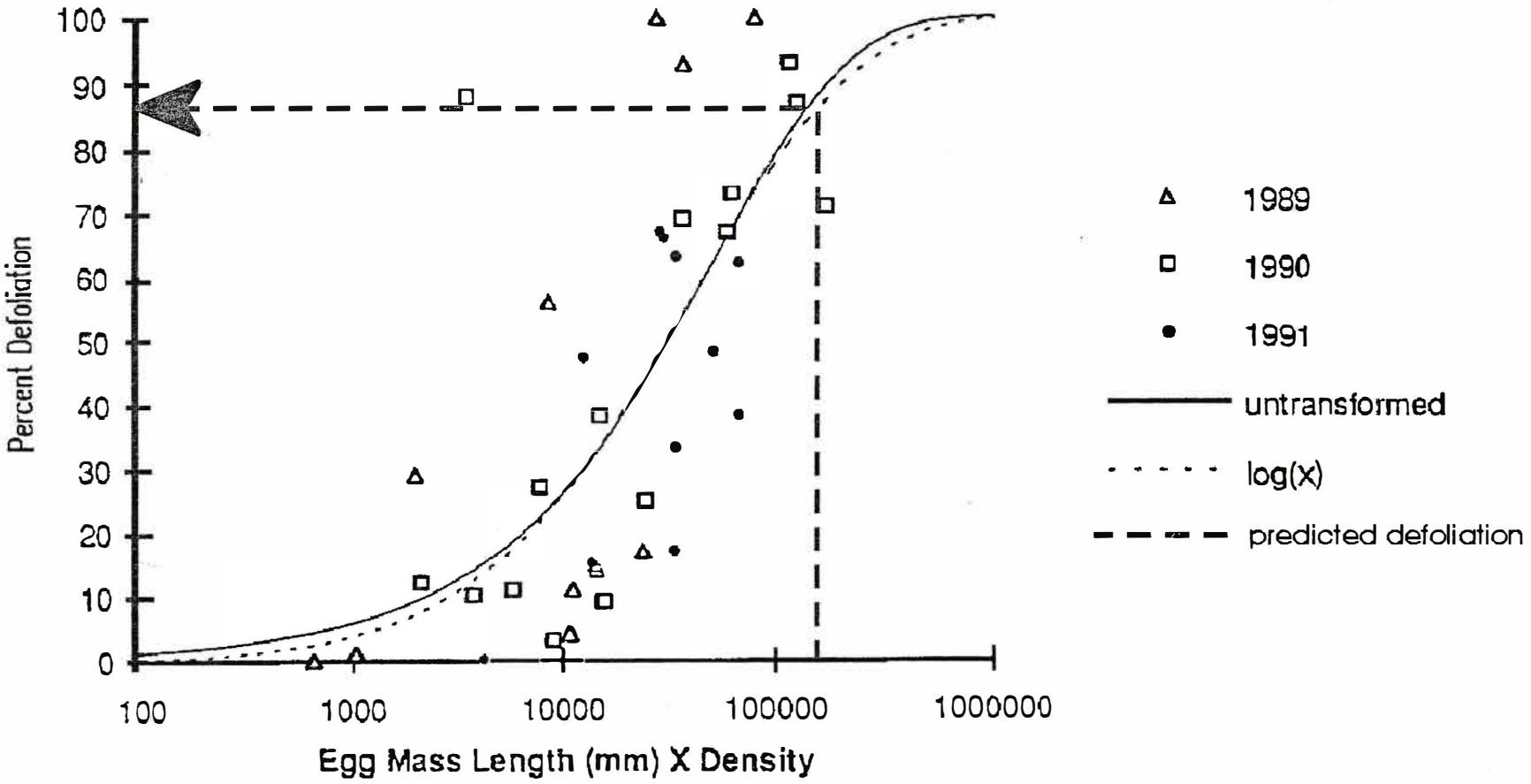
Accordingly, the estimated egg mass density of 6,105 egg masses per acre (egg mass density in Stand 6) x 34 mm (average length of egg masses in Stand 6) translates to a projected defoliation level of about 86 percent (heavy defoliation). Because egg mass densities and host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominately heavy throughout this stand. Table 3 shows the projected defoliation level in all the surveyed stands.

Egg masses longer than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. It is possible that either the gypsy moth fungus or the NPV could cause the collapse of defoliating levels of gypsy moth, however, it is unlikely that populations will collapse prior to a significant defoliation event occurring in 2002.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy in Stands 6, 9, 32, 67, 75, 77 and the southern portion of 62. Populations are low to non-existent in the other areas surveyed.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Figure 4.--Predicted defoliation in stand 6 in 2002 based on egg mass length and density.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of potential tree mortality. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28) percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality. Similar levels of mortality are likely at CMNWRC if severe defoliation occurs in addition to a dry growing season in 2002.

Gypsy moth defoliation also has a significant impact on mast production. The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

Management Options

For 2002, two management options have been evaluated for managing gypsy moth populations at CMNWRC. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent mast failure and tree mortality; and 2) reduce gypsy moth populations below treatment thresholds. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is unlikely that a collapse will occur prior defoliation since most of the areas are newly infested and there is an abundance of large healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that moderate and heavy defoliation will occur in these areas at CMNWRC in 2002 and gypsy moth will spread into stands at CMNWRC that are currently uninfested.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult to project treatment efficacy. Most often foliage protection can be achieved but sufficient reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, 3-5 days apart. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. However, sufficient quantities are available for use at CMNWRC should this option be selected.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1.	-No action
Alternative 2.	-One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.
Alternative 3	-Two aerial applications of *Btk*, as in alternative 2, applied 4-7 days apart.
Alternative 4	-Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations at CMNWRC are sufficient to cause areas of moderate and heavy defoliation in 2002. In order to protect tree foliage, mast production and prevent subsequent tree mortality, the recommendation is to implement Alternative 2 (a single application of Btk) on 57 acres and Alternative 3 (a double application of Btk) on 586 acres (Figure 5). The single application of Btk is to be applied in Stands 32, 75 and 77. The double application of Btk is to be applied in stands 6, 9, 69 and the southern portion of 62.

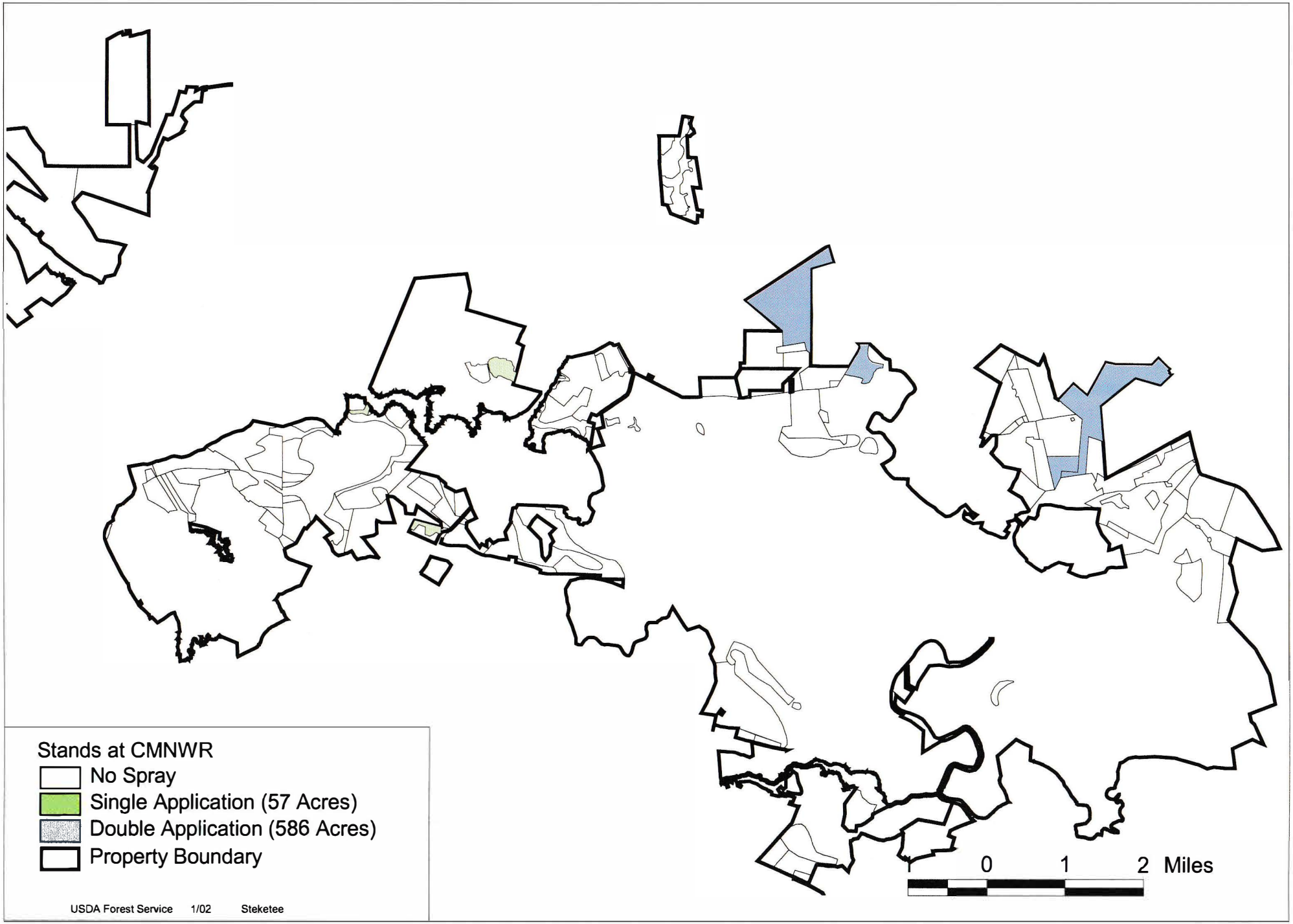
Only small and scattered areas of defoliation, if any, are expected elsewhere at CMNWRC in 2002.

This recommendation is based on the following considerations.

1) A single application of Btk will provide foliage protection and a population reduction in areas where populations appear to be building but densities are only moderate.

2) A double application of Btk is like to provide sufficient population reduction such that re-treatment in 2003 will not be necessary and adequate foliage protection in areas where population are high and appear to be building.

Figure 5. -- Recommended gypsy moth treatment blocks at Chesapeake Marshlands NWR Complex in 2002.



3) A double application of Gypchek on all 643 acres is likely to provide some foliage protection but significant reductions in population levels below treatment thresholds (750 egg masses/acre) is not likely to occur in areas with healthy gypsy moth populations that exceed 1,500 egg masses per acre.

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Table 1 – Gypsy moth egg mass survey results at Chesapeake Marshlands NWR Complex, Fall 2001.

Stand 1

Plot Number	Number Em/acre	Plot Number	Number Em/acre
1	0	5	0
2	0	6	0
3	0	7	0
4	0		

em/acre average = 0

Stand 3

Plot Number	Number Em/acre	Plot Number	Number Em/acre
8	0	10	0
9	0	11	0

em/acre average = 0

Stand 4

Plot Number	Number Em/acre	Plot Number	Number Em/acre
12	0	15	0
13	0	16	80
14	0	17	0

em/acre range = 0-80
em/acre average = 13

Stand 5

Plot Number	Number Em/acre	Plot Number	Number Em/acre
18	0	20	0
19	0	21	200

em/acre range = 0-200
em/acre average = 50

Stand 6

Plot Number	Number Em/acre	Plot Number	Number Em/acre
22	25,440	29	5,000
23	2,520	30	1,360
24	400	31	13,840
25	4,120	32	17,560
26	1,360	33	7,640
27	0	34	0
28	120		

em/acre range = 0-25,440
em/acre average = 6105

em size range (mm) = 19-59
em size average (mm) = 34

Stand 7

Plot Number	Number Em/acre	Plot Number	Number Em/acre
35	120	40	0
36	0	41	0
37	0	42	0
38	0	43	40
39	0		

em/acre range = 0-120
em/acre average = 18
em size range (mm) = 26-28
em size average (mm) = 27

Stand 9

Plot Number	Number Em/acre	Plot Number	Number Em/acre
44	0	48	0
45	17,200	49	11,600
46	1,720	50	240
47	240		

em/acre range = 0-17,200
em/acre average = 4,429
em size range (mm) = 28-41
em size average (mm) = 34

Stand 10

Plot Number	Number Em/acre
51	0
52	0
53	0

em/acre average = 0

Stand 11

Plot Number	Number Em/acre
54	0
55	0
56	280

em/acre = 0-280
em/acre average = 93

Stand 12

Plot Number	Number Em/acre	Plot Number	Number Em/acre
57	0	64	0
58	0	65	120
59	0	66	0
60	0	67	120
61	0	68	280
62	0	69	40
63	0		

em/acre range = 0-280
em/acre average = 43
em size range (mm) = 24-28
em size average (mm) = 26

Stand 13

Plot Number	Number Em/acre
70	0
71	0
72	0

em/acre average = 0

Stand 21

Plot Number	Number Em/acre
73	0
74	0
75	0

em/acre average = 0

Stand 23

Plot Number	Number Em/acre
76	0
77	0
78	0

em/acre average = 0

Stand 27

Plot Number	Number Em/acre
79	40
80	0
81	0

em/acre = 0-40
em/acre Average = 13

Stand 29

Plot Number	Number Em/acre	Plot Number	Number Em/acre
82	0	85	0
83	0	86	0
84	0	87	0

em/acre average = 0

Stand 32

Plot Number	Number Em/acre
88	400
89	440
90	2,480

em/acre range = 400-2,480
em/acre average = 1,107
em size range (mm) = 26-36
em size average (mm) = 30

Stand 33

Plot Number	Number Em/acre
91	0
92	0

em/acre average = 0

Stand 34

Plot Number	Number Em/acre
93	0
94	0

em/acre average = 0

Stand 35

Plot Number	Number Em/acre	Plot Number	Number Em/acre
95	0	99	0
96	40	100	0
97	0	101	0
98	0	102	0

em/acre range = 0-40
em/acre average = 8

Stand 37

Plot Number	Number Em/acre	Plot Number	Number Em/acre
103	0	106	0
104	0	107	0
105	0	108	0

em/acre average = 0

Stand 39

Plot Number	Number Em/acre
109	0
110	40

em/acre = 0-40
em/acre average = 20

Stand 40

Plot Number	Number Em/acre
111	320
112	0
113	0

em/acre = 0-320
em/acre average = 107

Stand 41

Plot Number	Number Em/acre	Plot Number	Number Em/acre
114	0	116	0
115	0	117	0

em/acre average = 0

Stand 44

Plot Number	Number Em/acre
118	360
119	80

em/acre = 0-360

em/acre average = 220

Stand 51

Plot Number	Number Em/acre	Plot Number	Number Em/acre
120	0	122	0
121	0	123	0

em/acre average = 0

Stand 56

Plot Number	Number Em/acre	Plot Number	Number Em/acre
124	0	126	0
125	0		0

em/acre average = 0

Stand 57

Plot Number	Number Em/acre
128	0
129	0

em/acre average = 0

Stand 58

Plot Number	Number Em/acre	Plot Number	Number Em/acre
130	0	133	0
131	0	134	0
132	0	135	0

em/acre average = 0

Stand 60

Plot Number	Number Em/acre
136	0
137	0
138	0

em/acre average = 0

Stand 61

Plot Number	Number Em/acre	Plot Number	Number Em/acre
139	0	142	0
140	0	143	0
141	0		

em/acre average = 0

Stand 62

Plot Number	Number Em/acre	Plot Number	Number Em/acre
144	0	148	3,280
145	0	149	80
146	0	150	80
147	0		

em/acre range = 0-3,280
em/acre average = 491
em size range (mm) = 21-37
em size average (mm) = 28

Stand 63

Plot Number	Number Em/acre	Plot Number	Number Em/acre
151	0	154	0
152	720	155	920
153	0		

em/acre range = 0-920
em/acre average = 328
em size range (mm) = 19-24
em size average (mm) = 22

Stand 64

Plot Number	Number Em/acre	Plot Number	Number Em/acre
156	0	160	0
157	0	161	40
158	0	162	0
159	0		

em/acre range = 0-40
em/acre average = 6

Stand 65

Plot Number	Number Em/acre	Plot Number	Number Em/acre
163	0	167	0
164	0	168	0
165	0	169	0
166	0		

em/acre average = 0

Stand 66

Plot Number	Number Em/acre	Plot Number	Number Em/acre
170	0	177	0
171	0	178	0
172	0	179	0
173	0	180	0
174	0	181	280
175	0	182	0
176	0	183	0

em/acre range = 0-280
em/acre average = 20
em size range (mm) = 24-28
em size average (mm) = 26

Stand 67

Plot Number	Number Em/acre	Plot Number	Number Em/acre
184	0	195	3,520
185	0	196	3,960
186	0	197	9,520
187	0	198	1,160
188	7,920	199	2,320
189	880	200	400
190	440	201	10,480
191	0	202	48,480
192	4,120	203	6,300
193	1,360	204	13,800
194	1,160		

em/acre range = 0-48,480
em/acre average = 5,518
em size range (mm) = 21-49
em size average (mm) = 30

Stand 68

Plot Number	Number Em/acre	Plot Number	Number Em/acre
205	0	208	0
206	0	209	80
207	0		

em/acre range = 0-80
em/acre average = 16

Stand 69

Plot Number	Number Em/acre	Plot Number	Number Em/acre
210	440	213	160
211	280	214	120
212	0		

em/acre range = 0-440
em/acre average = 200
em size range (mm) = 19-36
em size average (mm) = 27

Stand 70

Plot Number	Number Em/acre
215	0
216	280

em/acre range = 0-280
em/acre average = 140

Stand 71

Plot Number	Number Em/acre	Plot Number	Number Em/acre
217	0	219	0
218	0	220	0

em/acre average = 0

Stand 72

Plot Number	Number Em/acre	Plot Number	Number Em/acre
221	0	228	0
222	0	229	0
223	0	230	0
224	0	231	0
225	0	232	0
226	0	233	0
227	0		

em/acre average = 0

Stand 73

Plot Number	Number Em/acre
234	0
235	0
236	0

em/acre average = 0

Stand 74

Plot Number	Number Em/acre	Plot Number	Number Em/acre
237	200	241	0
238	280	242	0
239	0	243	0
240	0		

em/acre range = 0-280
em/acre average = 69

em size range (mm) = 30-32
em size average (mm) = 31

Stand 70

Plot Number	Number Em/acre
215	0
216	280

em/acre range = 0-280
em/acre average = 140

Stand 71

Plot Number	Number Em/acre	Plot Number	Number Em/acre
217	0	219	0
218	0	220	0

em/acre average = 0

Stand 72

Plot Number	Number Em/acre	Plot Number	Number Em/acre
221	0	228	0
222	0	229	0
223	0	230	0
224	0	231	0
225	0	232	0
226	0	233	0
227	0		

em/acre average = 0

Stand 73

Plot Number	Number Em/acre
234	0
235	0
236	0

em/acre average = 0

Stand 74

Plot Number	Number Em/acre	Plot Number	Number Em/acre
237	200	241	0
238	280	242	0
239	0	243	0
240	0		

em/acre range = 0-280
em/acre average = 69
em size range (mm) = 30-32
em size average (mm) = 31

Stand 75

Plot Number	Number Em/acre	Plot Number	Number Em/acre
244	720	248	0
245	2,320	249	1,120
246	480	250	1,200
247	1,400		

em/acre range = 0-2,320
em/acre average = 1,207
em size range (mm) = 19-36
em size average (mm) = 28

Stand 76

Plot Number	Number Em/acre
251	0
252	0
253	0

em/acre average = 0

Stand 77

Plot Number	Number Em/acre	Plot Number	Number Em/acre
254	1,080	257	1,920
255	2,760	258	1,280
256	880	259	3,040

em/acre range = 880-3,040
em/acre average = 1,827
em size range (mm) = 19-36
em size average (mm) = 29

Table 2 – Comparison of pre-treatment and post-treatment egg mass densities at Chesapeake Marshlands NWR Complex.

Stand Number	Average Em/acre 2000 (pre-treatment)	Average Em/acre 2001 (post-treatment)	Percent Change
3	860	0	- 100
4	5,896	13	- 99.8
7	1,480	0	- 100
10	880	0	- 100
11	1,540	93	- 93
12	2,331	43	- 98
13	2,887	0	- 100
27	907	13	-99
29	3,740	0	-100
33	2,920	0	-100
34	2,667	0	-100
35	4,020	8	-99.8
37	2,904	0	-100
51	1,120	0	-100
64	2,912	0	-100
66	2,840	20	-99.3
69	560	200	-64
70	3,600	140	-96
71	3,120	0	-100
72	3,600	0	-100
74	5,450	69	-99
All Treated Stands	2,676	29	-99

Table 3 – Projected defoliation levels for each surveyed stand at Chesapeake Marshlands NWR Complex in 2002.

Projected Defoliation		
Stand Number	Percent Defoliation	Defoliation Class
6	86%	heavy
9	81%	heavy
62*	78%	heavy
67	82%	heavy
32	36%	moderate
75	37%	moderate
77	48%	moderate
4	2%	low
5	5%	low
11	6%	low
12	8%	low
27	2%	low
35	1%	low
39	2%	low
40	8%	low
44	15%	low
62**	3%	low
63	18%	low
64	1%	low
66	3%	low
68	2%	low
69	11%	low
70	9%	low
74	7%	low

No defoliation is expected in stands 1, 3, 13, 21, 23, 29, 33, 34, 37, 41, 51, 56, 57, 58, 60, 61, 65, 71, 72, 73 and 76

* = southern portion
** = most of stand